POPULATION AND DISTRIBUTION OF BRONZEWINGED (*METOPIDIUS INDICUS*) AND PHEASANT-TAILED (*HYDROPHASIANUS CHIRURGUS*) JACANAS IN KEOLADEO NATIONAL PARK, BHARATPUR, RAJASTHAN[1]

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(*With four text-figures*)

Key words: *Metopidius indicus, Hydrophasianus chirurgus,* macro-invertebrate, PCA, population, spatial distribution.

The temporal and spatial patterns of the population of two species of jacana (*Metopidius indicus* and *Hydrophasianus chirurgus*) were studied in a monsoonal wetland (Keoladeo National Park, Bharatpur, Rajasthan) of the Gangetic plains of India for three years. The population of both the species varied significantly over seasons and years, usually rising during monsoon-winter. The Pheasant-tailed had the highest number in 1988, and for the Bronzewinged in 1986. The spatial distribution of jacanas inside the Park was not determined by the size of the aquatic blocks. Both the species had particular patterns of distribution which correspond with the distribution pattern of certain macro-invertebrate taxa.

Introduction

Detailed information on the ecology of most Jacanidae, a circum-tropical family of shorebirds that inhabit freshwater swamps and marshes, is very scanty. This family comprises eight species and possesses a number of unique characteristics, the most outstanding of which are their exceedingly long toes and claws which allow them to walk with ease over floating vegetation (Austin 1983).

The species which occur on the Asian continent are pheasant-tailed jacana (*Hydrophasianus chirurgus*) and bronzewinged jacana (*Metopidius indicus*). The general distribution of both pheasant-tailed and bronzewinged jacanas in the Indian subcontinent was reported by Ali and Ripley (1983) and their population has been estimated as part of the Asian waterfowl census (Scott and Rose 1989). However, intensive studies on the population and distribution in a specific area have not been attempted so far. Therefore, a three year study was undertaken at Keoladeo National Park, Bharatpur to look into the spatio-temporal aspects of their population.

The spatial abundance of jacanas in the Park did not have a positive linear relation to the aquatic area, as smaller blocks had more birds than did the larger blocks. Many researchers have emphasized the role of macro-invertebrates in the habitat preference of different waterfowl species, especially during the breeding season (Murkin 1979, 1982, Murkin and Kadlec 1986, Murkin and Batt (1987). Therefore, a spatial correspondence between the distribution of jacanas and macro-invertebrate taxa inside the Park is expected during their breeding season. This correspondence is examined using principal component analysis.

Study Area

The study was conducted in Keoladeo National Park, Bharatpur, a well known, man-

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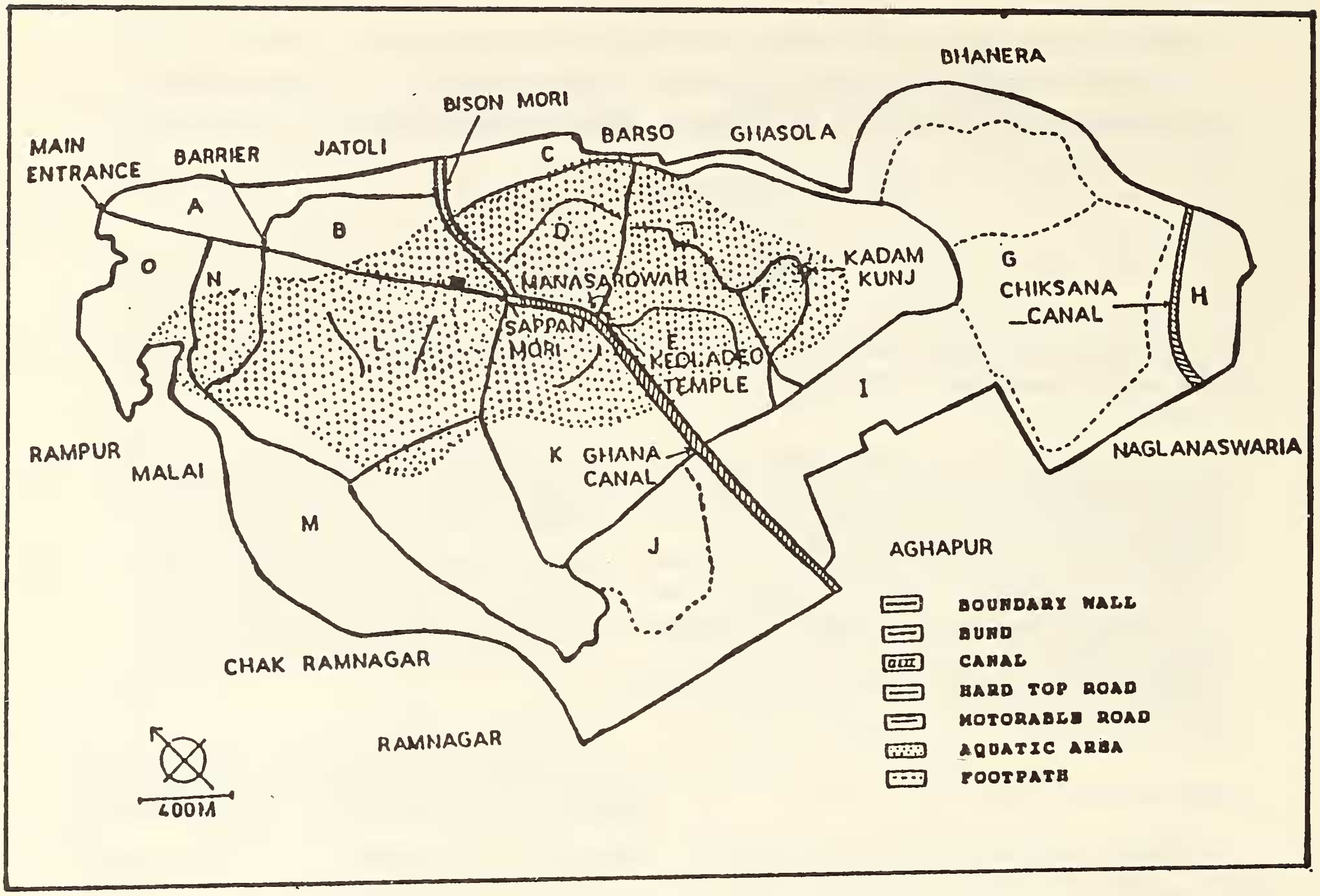

Fig. 1 Map of Keoladeo National Park

modified wetland situated in the Indogangetic plains. The Park is situated between 27° 7.6' & 27° 12.2' N, and 77° 29.5' & 77° 33.9' E in Rajasthan. The total area of the Park is 29 sq. km. It is almost flat with a gentle slope towards the centre forming a depression and, during the years of normal rainfall and water supply, the inundated area covers around 8.5 sq. km. The aquatic portion of the Park has been divided into various unequal compartments or blocks by means of dykes (Fig. 1). The Park receives water annually from a reservoir — the Ajan bund — situated about 500 m south of the Park.

Bharatpur receives the southwest monsoon which sets in towards end-June and continues upto September, sometimes to October. The total rainfall was 424.7, 423.4 and 614.2 mm during 1986, 1987 and 1988 respectively. The monthly rainfall varied from year to year (Fig. 2).

Material and Methods

Fortnightly census was conducted in the morning hours using the dykes as transects. All the birds seen on either side of the dykes were counted, using a pair of binoculars. Duplication of sighting was assumed to be nil, as the species concerned restrict themselves to the same area once they are settled. The entire aquatic area was surveyed in each census trip.

Macro-invertebrates were sampled weekly from fixed sampling stations (Fig. 1) using a modified version of the Wisconsin Trap (Clark and Murkin 1989). The radius of the sampler was 7.5 cm. It was immersed in water for some time, so as to nullify the disturbance caused by the movement of the sampler, as well as boat, and then taken out gently. The contents along with the vegetation and other material present inside the sampler were washed carefully into a sieve

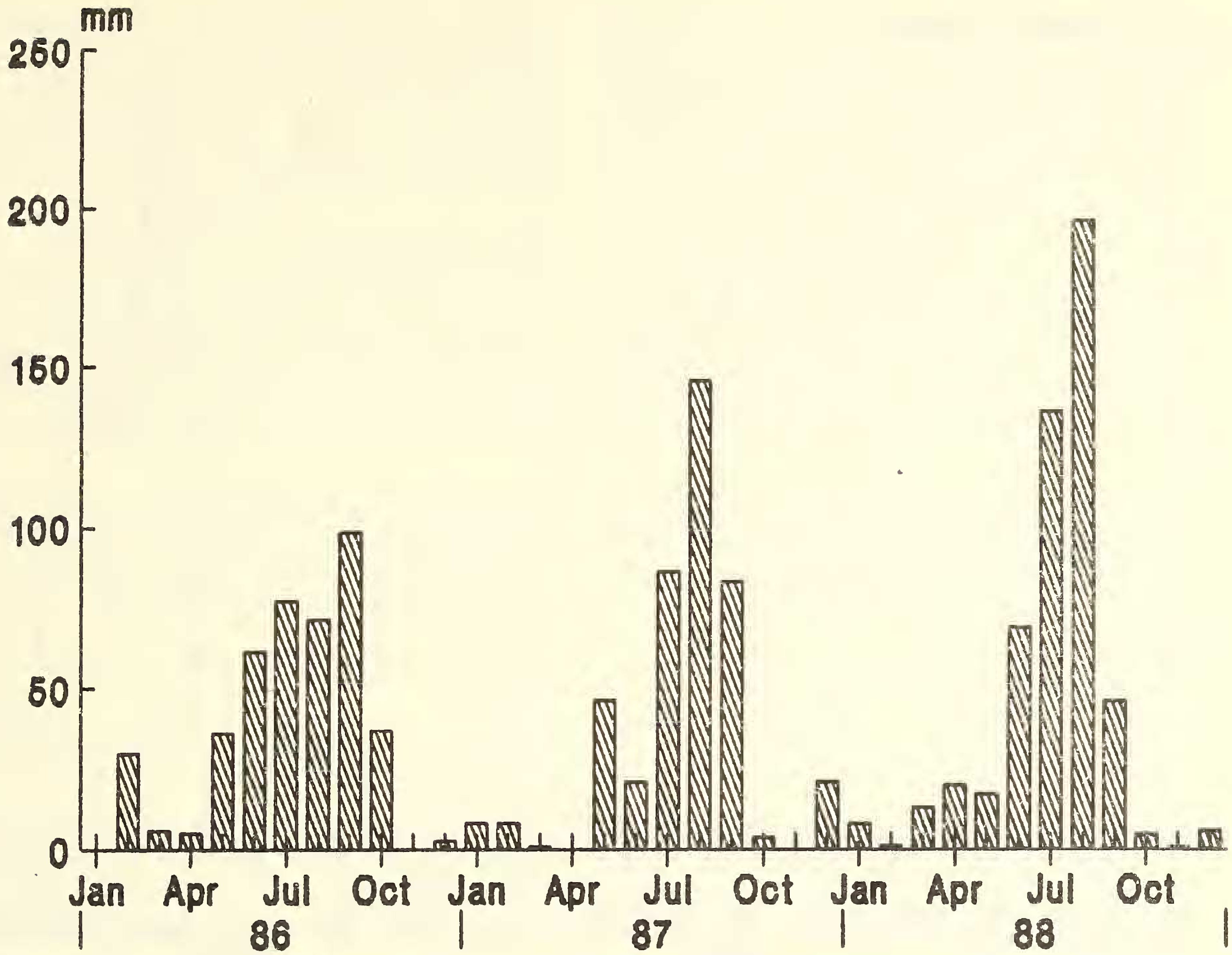

Fig. 2 Monthly variation of rainfall in the Park from 1986 to 1988

and the macro-invertebrates were hand-picked from it. Insects were identified up to order level and counted.

Statistical analysis

Analysis of variance (ANOVA) was used to compare the population mean of jacanas over the years. The differences of population between years were also tested using ANOVA. To compare the mean of population of both the species in a given a year, paired sample t-test was used.

Similarly, ANOVA was used to determine the overall differences in the population of jacanas among the blocks. Newman-Keuls test was used for the multiple comparison of blocks to identify the pairs of blocks which differ significantly. All statistical analyses were done using the software SYSTAT (Wilkinson 1988).

Multivariate analysis

Data on the population of jacanas were sorted out block-wise and correlated with different macro-invertebrate taxa in order to identify the taxa influencing the spatial pattern of the distribution of jacanas. Only the data for the monsoon and winter (August to March) were taken into consideration. This was deemed necessary for avoiding the effect of seasons in the analysis. Three such seasons, starting from August 1986, and ending with December 1988, were included in the principal component

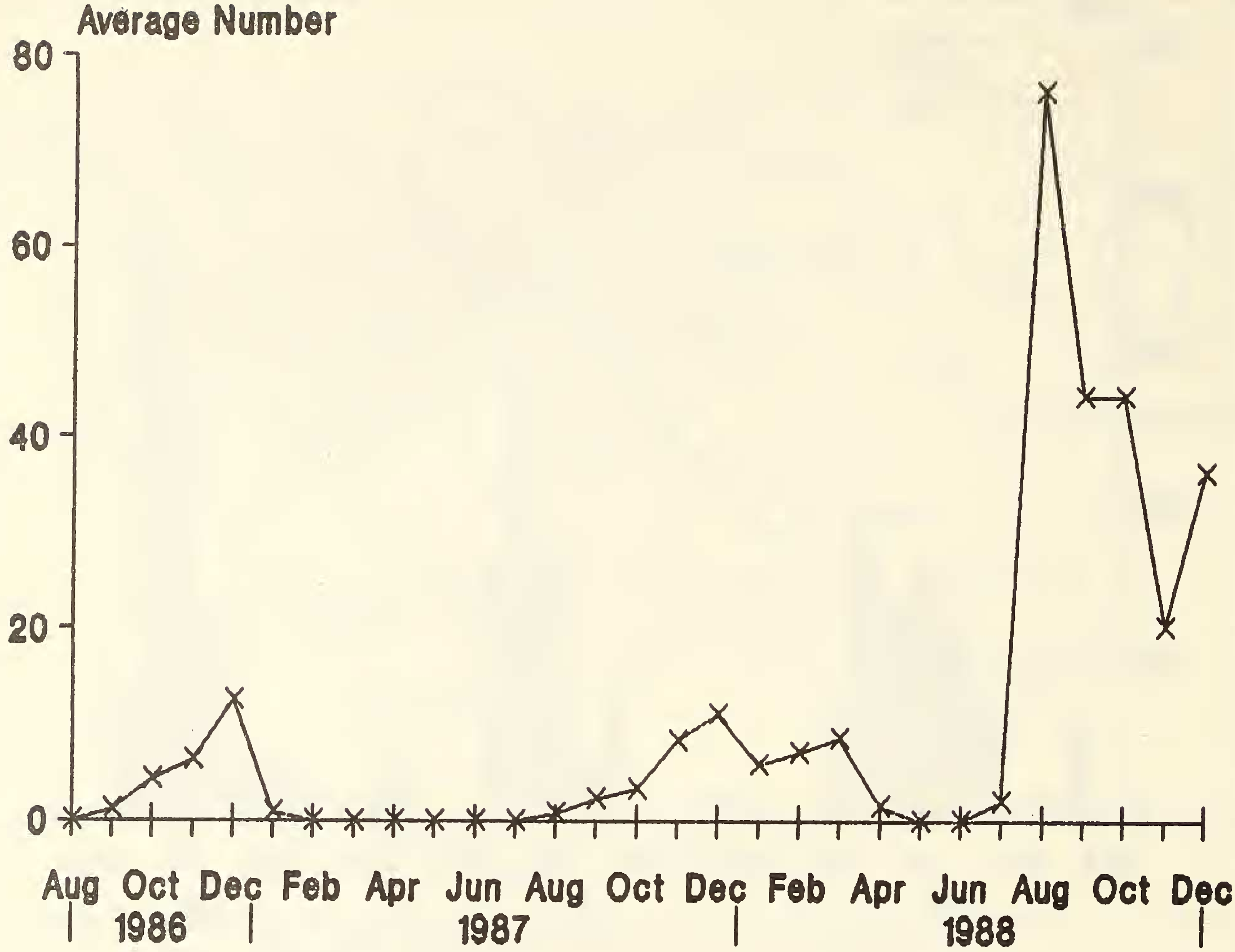

Fig. 3 Population of the Pheasant-tailed jacana from 1986 to 1988

analysis. To begin with, principal component analysis was done on each data set which included block wise data on both species of jacana and abundance of different macro-invertebrate taxa. The components derived from each data set represent the spatial variability of a particular data set. The analysis began with the extraction of the first principal component which is the linear function of the eight variables accounting the highest variation. The analysis then proceeds with computation of the next component and so on, till all the variabilities in the data set were accounted for. All the components were extracted from the original data set containing of 42 observations independent of one another. The first component of each data set was taken for further analysis. Thus, the first principal component of each jacana species was correlated with the first components of each macro-invertebrate taxa. The significance of the correlation coefficients was obtained with 40 degrees of freedom (Jeffers 1987).

Results and Discussion

Population of the Pheasant-tailed Jacana.

Population of the pheasant-tailed jacana had a distinct seasonal pattern: the number shot up in autumn and winter, decreased in the spring and was totally absent during summer (Fig. 3). Ali and Ripley (1983) observe that the pheasant-tailed jacana is a local migrant and can be seen in good numbers in the plains during autumn-winter. The pattern obtained during this study support their observation.

The population of the pheasant-tailed varied significantly in 1988, from that of 1986, and 1987, thereby making the total variation significant (ANOVA, F = 58.98; P = 0.0001). The contribution of variation from 1986 vs. 1987 was not significant to the over all variation (Table 1). Their population was high during monsoon and winter of 1988 compared to that of 1986 and 1987 {x = 12 (1986), 5.82 (1987), 44 (1988)}. During 1988 they bred inside the Park, unlike in 1986 and 1987. The failure of breeding in 1987 may be due to poor monsoon. But 1986, was partially good in terms of rain and water input to the Park. Thus, the absence of nesting in this year cannot be attributed to the monsoon. Instead, it might be the result of abundant growth of *Eichhornia crassipes*. Thus, yearly fluctuation in the population of the pheasant-tailed jacana must be a combined effect of monsoon and the availability of suitable habitat (Ramachandran 1993).

TABLE 1
COMPARISON TO DETERMINE THE CONTRIBUTION BY INDIVIDUAL YEARLY VARIATION TO THE TOTAL YEARLY VARIATION IN THE POPULATION OF PHEASANT-TAILED JACANA.

	1986 vs 1987	1986 vs 1988	1987 vs 1988
F value	0.592	100.888	90.015
Probability	0.446	0.0001	0.0001

Population of the Bronzewinged Jacana.

The population of the bronzewinged jacana also had a distinct, but different seasonal variation from that of the pheasant-tailed jacana (Fig. 4). Their population started building up in August and attained a peak in October, December and November during 1986, 1987 and 1988 respectively. During autumn and winter (September through December) the number did not show much change as in other seasons. From January the population started declining and reached the lowest point during summer, especially in May and June.

Significant variation in the population of the bronzewinged was noticed in different years (ANOVA, F = 8.00 P = 0.001). It was striking between 1986 and 1987, and 1986 and 1988 but not so between 1987 and 1988 (Table 2). In contrast to the population of the pheasant-tailed jacana, the population of bronzewinged was maximum during the monsoon and winter of 1986 (Table 2), which was mainly due to their breeding success. Their preferred habitat for nesting — *Eichhornia crassipes* patches — was abundant during this season in 1986. Barman and Bhattacharjee (1993) also reported the importance of *Eichhornia sp.* for bronzewinged as the preferred cover besides *Hymanachae* sp. During 1987, the population declined because of the failure of the monsoon, whereas during the monsoon and winter of 1988, they could not breed in good numbers (only one nest and two families with chicks were sighted) as the habitat was unsuitable. The near total absence of *Eichhornia crassipes* and *Ipomoea aquatica* might have been the reason for their decreased nesting activity. It may be noted that while the bronzewinged use mainly *Eichhornia crassipes* patches for nesting, they use *Ipomoea aquatica* as a cover for themselves and their young ones from predators.

TABLE 2
COMPARISON TO DETERMINE THE CONTRIBUTION BY INDIVIDUAL YEARLY VARIATION TO THE TOTAL YEARLY VARIATION IN THE POPULATION OF BRONZEWINGED JACANA

	1986 vs 1987	1986 vs 1988	1987 vs 1988
F value	12.723	10.298	0.017
Probability	0.001	0.003	0.898

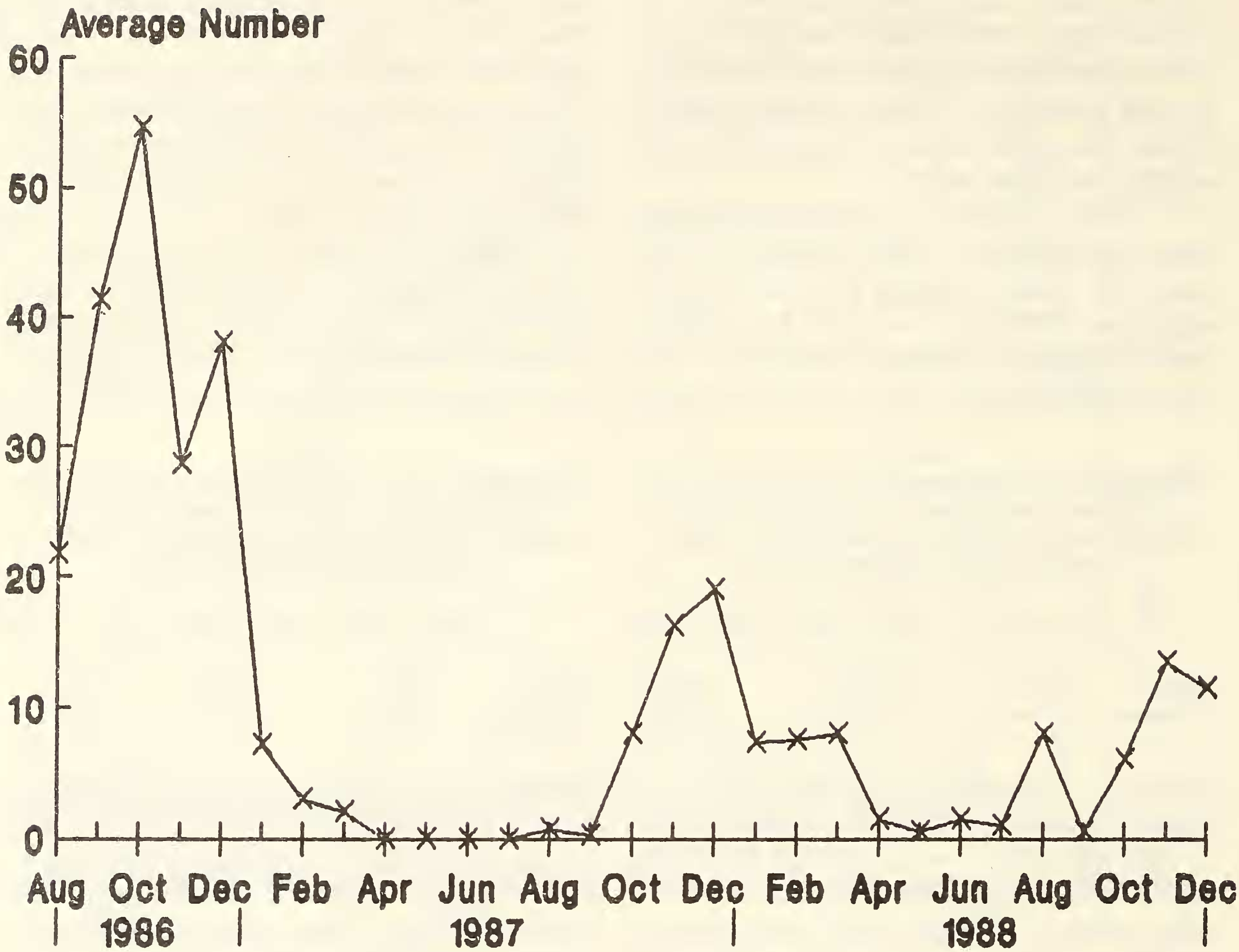

Fig. 4 Population of the Bronzewinged jacana from 1986 to 1988

Comparison of population of the Pheasant-tailed and the Bronzewinged Jacanas

The population of both the species varied significantly during the monsoon and winter of 1986 and 1988, whereas in 1987 it did not vary (Table 3). Thus, the year 1986 was productive for the bronzewinged and 1988 for the pheasant-tailed but 1987 was not particularly so for either of the species. Since both 1986 and 1988 had more or less similar rainfall, it cannot be considered as a factor for the difference in population between the two species. Therefore, it can be explained only by the different habitat requirement of both species and the availability of preferred habitat patches.

TABLE 3
PAIRED SAMPLES T-TEST SHOWING VARIATION BETWEEN THE PHEASANT-TAILED AND BRONZEWINGED JACANAS IN THE SAME YEAR

	Year		
Parameters	1986	1987	1988
Mean Difference	21.429	2.735	-36.100
Sd Difference	17.188	5.966	22.158
t-statistics	4.987	1.890	-5.152
Degree of freedom	15.000	16.000	9.000
Probability	0.0001	0.077	0.001

Distribution of the Pheasant-tailed Jacana

The highest mean number of the pheasant-tailed was sighted in block D and lowest in block

B. The blocks E and F held the same number of the pheasant-tailed jacana (Table 4). Similarly blocks N and Lw, and L and K had the same average population. However, the population varied significantly between many of the blocks (ANOVA: F = 7.47, P = 0.0001).

Table 4
MEAN FOR THE BLOCK-WISE POPULATION OF JACANAS (n = 42).

Blocks	Pheasant-tailed jacana	Bronzewinged jacana
N	0.3	0.5
Lw	0.3	0.6
L	0.6	4.0
B	0.1	0.4
K	0.8	1.5
D	5.2	3.5
E	3.5	3.2
F	3.2	0.9

The multiple comparison of absolute mean using Newman-Keuls test (Table 5) showed that blocks D, E and F differed significantly from all other blocks and at the same time did not vary among themselves.

Distribution of the Bronzewinged Jacana.

The highest mean population of the bronzewinged was in block L followed by D and E. The blocks N, Lw, and B held almost the same mean population (Table 4). In this species also, there was significant difference in its population between blocks (ANOVA: F = 5.98, P = 0.000).

As in the pheasant-tailed multiple comparison of blocks was attempted (Table 6). The analysis showed that block D differed from blocks N, Lw, L and B'; block E from blocks N, Lw, B and K; and block F from blocks L, D and E. The blocks B and K differed from L, and L from N and Lw.

The role of macro-invertebrate taxa in the distribution pattern of the bronzewinged and pheasant-tailed jacanas.

Eight taxa of macro-invertebrates were recorded from the Park comprising six insect orders, molluscs and oligochaetes (Table 7). The first principal component obtained for each taxa of macro-invertebrate and the jacanas with the total variation explained is given in Table 8 and 9 respectively.

When the first principal component obtained for pheasant-tailed jacana was subjected to correlational analysis (Table 10) with that of different macro-invertebrate taxa, it was found that the spatial pattern of this species positively corresponds with the spatial pattern of Odonata, Mollusca and Oligochaeta. But its relation with the Ephemeroptera was negative. Its relation with Mollusca is striking because in a year when the

Table 5
NEWMAN-KEULS MULTIPLE COMPARISON OF THE DISTRIBUTION OF PHEASANT-TAILED JACANA IN VARIOUS BLOCKS

BLOCKS	N	Lw	L	B	K	D	E	F
N	0.000							
Lw	0.048	0.000						
L	0.351	0.304	0.000					
B	0.155	0.202	0.506	0.000				
K	0.543	0.495	0.192	0.698	0.000			
D	4.913*	4.865*	4.561*	5.067*	4.370*	0.000		
E	3.202**	3.155**	2.851**	3.357**	2.659**	1.710	0.000	
F	2.988**	2.940**	2.637**	3.143**	2.445**	1.925	0.214	0.00

Note: the values are absolute mean differences
* P = 0.000; ** P <0.02

TABLE 6

NEWMAN-KEULS MULTIPLE COMPARISON OF THE DISTRIBUTION OF BRONZEWINGED JACANA IN VARIOUS BLOCKS

BLOCKS	N	Lw	L	B	K	D	E	F
N	0.000							
Lw	0.147	0.000						
L	3.577*	3.431*	0.000					
B	0.114	0.261	3.691*	0.000				
K	1.044	0.897	2.533***	1.158				
D	3.040*	2.893*	0.538*	3.154*	1.996	0.000		
E	2.737**	2.590**	0.841	2.850**	1.692+	0.303	0.000	
F	0.444	0.297	3.134*	0.558	0.600	2.596*	2.293***	0.000

* P = 0.00; ** P = 0.01; *** P = 002; + P = 0.05

Note: the values are absolute mean differences.

TABLE 7

AVERAGE NUMBER OF DIFFERENT MACRO-INVERTEBRATE TAXA IN DIFFERENT BLOCKS OF THE PARK (n = 42)

Taxa	Blocks							
	B	D	E	F	K	L	Lw	N
Coleoptera	0.18	0.89	0.46	0.19	0.25	0.77	0.14	0.11
Diptera	0.45	0.33	0.31	0.69	0.21	0.27	0.41	0.18
Ephemeroptera	0.04	0.19	0.20	0.13	0.15	0.21	0.16	0.08
Hemiptera	0.37	1.04	0.66	0.60	0.71	0.79	0.38	0.09
Lepidoptera	0.19	0.37	0.59	1.25	0.48	0.37	0.28	0.14
Odonata	0.95	0.71	1.95	1.80	2.14	0.68	0.67	0.35
Mollusca	0.38	3.52	1.48	0.19	0.75	1.75	1.16	0.06
Oligochaeta	0.26	0.23	0.60	0.86	0.35	0.15	0.29	0.20

TABLE 8

THE FIRST COMPONENT AND THE PROPORTION OF VARIATION ACCOUNTED FOR EACH MACRO-INVERTEBRATE TAXA

Blocks	COL	DIP	EPH	HEM	LEP	ODO	OLI	MOL
B	0.85	0.87	0.16	0.87	0.35	0.56	0.45	0.84
D	0.67	0.05	0.51	0.64	0.93	0.52	0.57	0.31
E	0.83	0.71	0.39	0.42	0.79	0.79	0.72	0.80
F	0.19	0.64	0.23	0.72	0.40	0.85	0.90	0.74
K	0.34	-0.12	0.08	0.80	0.49	0.69	0.75	0.56
L	0.56	0.56	0.84	0.34	0.89	0.54	0.67	0.36
Lw	0.72	-0.11	-0.06	0.63	0.60	0.35	0.85	0.56
N	0.07	0.32	0.76	-0.15	0.03	0.77	0.85	0.00
% of Vari. Exaplained	35.38	26.38	22.23	38.03	39.63	42.49	53.71	34.27

Note: COL = Coleoptera, DIP = Diptera, EPH = Ephemeroptera, HEM = Hemiptera, LEP = Lepidoptera, ODO, Odonata, OLI = Oligochaeta, MOL = Mollusca

TABLE 9
THE FIRST PRINCIPAL COMPONENT OBTAINED FOR THE BRONZEWINGED AND THE PHEASANT-TAILED JACANA.

BLOCK	Bronzewinged jacana	Pheasant-tailed jacana
B	0.119	0.453
D	0.422	0.509
E	0.807	0.832
F	-0.157	0.798
K	0.921	0.660
L	0.844	0.394
Lw	-0.021	0.604
N	-0.288	0.578
% Vari. Explained	31.416	38.548

TABLE 10
COEFFICIENTS OF CORRELATION BETWEEN THE FIRST PRINCIPAL COMPONENT OF THE BRONZEWINGED AND THE PHEASANT-TAILED JACANA AND THE FIRST PRINCIPAL COMPONENT OF VARIOUS MACRO-INVERTEBRATE TAXA

Taxa	Bronzewinged jacana	Pheasant-tailed jacana
Coleoptera	0.371*	-0.197
Diptera	-0.071	0.045
Ephemeroptera	0.101	-0.373*
Hemiptera	0.217	0.065
Lepidoptera	0.685*	-0.125
Odonata	-0.035	0.655*
Mollusca	0.199	0.406*
Oligochaeta	-0.336*	0.590*

* significant at P = 0.05

abundance of Mollusca inside the Park was very poor, the pheasant-tailed chose to breed in an artificial village pond in Banera. 50 m away from the boundary of the Park, where the molluscs were abundant. None of the taxa showed any significant correspondence with the pheasant-tailed. Since some other factors also contribute to the variability in the distribution of this species, the combined effect of all these may be the reason for the pattern observed, or all the correlated macro-invertebrate components may be inter-related in their distributional pattern.

In the case of the bronzewinged, the first principal component had significant positive relation to Coleoptera and Lepidoptera, but negative to Oligochaeta (Table 10). The negative relation of Oligochaeta may be due to the negative relation of this taxa with other positively related taxa. It need not be the result of direct interaction between the bronzewinged and Oligochaeta.

Invertebrate food resources are an important factor in determining the waterfowl and blackbird (*Xanthocephalus xanthocephalus* and *Agelaius phoeniceus*) use of prairie wetlands, particularly during the breeding season (Murkin, 1979; Murkin and Kadlec, 1986; Murkin and Batt, 1987). Habitat preferences of breeding black ducks (*Anas rubriceps*) appear to be influenced by the cover and invertebrate densities ((Ringelman *et al.*, 1982). They indicated that the ducks avoided wetland habitat types having low invertebrate densities. Similarly the distribution of jacanas inside the Park in a given season may be explained by three major factors, namely distribution of vegetation patches, macro-invertebrate fauna and water depth, or combined effect of all these factors. Among the above mentioned variables, variability of water depth among the different blocks in any particular season was negligible and the distribution of macro-invertebrates is defined by the characteristics of vegetation patches as recorded by Jeffries (1993). The importance of a macro-invertebrate diet in fulfilling the protein demand of ducks, especially from the pre-laying period to egg-laying period has been documented earlier (Swanson and Meyer 1973, Krapu 1974, Swanson *et al.* 1979, Noyes and Jarvis 1985). Moreover, Barman and Bhattacharjee (1993) found animal food as the most preferred item for the bronzewinged jacana. Hence, macro-invertebrate can be a good predictor variable for the spatial distribution patterns of waterbirds, especially during their breeding season.

The correlation obtained between the distribution of jacana species and the distribution of various macro-invertebrate taxa indicates that jacanas might be fulfilling their protein demand by feeding opportunistically on them. Baldessarre and Bolen (1994) had come to the same conclusion in the case of waterfowl.

Whilst correspondence has been documented in the spatial distribution of both the species of jacanas and various macro invertebrate taxa by this study, it is to be mentioned that the observed relation cannot be explained fully until quantitative data on their food habits are available. Nevertheless, correspondence of their occurrence with a particular taxon of macro-invertebrate suggests that they should be feeding on it.

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